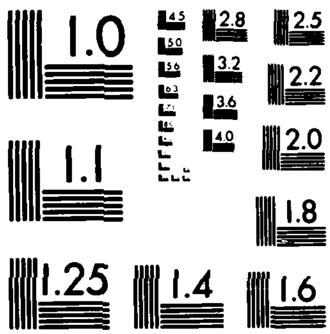
AD-A150 730   FABRY-PEROT INTERFEROMETER AND SKYMAPPING PHOTOMETER   1/1
DETERMINATIONS OF MI..(U) PITTSBURGH UNIV PA DEPT OF
PHYSICS AND ASTRONOMY M A BIONDI 26 OCT 84

UNCLASSIFIED   AFGL-TR-84-0280 F19628-83-K-0036   F/G 4/1   NL

END
FILMED
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AFGL-TR-84-0280

FABRY-PEROT INTERFEROMETER AND SKYMAPPING PHOTOMETER DETERMINATIONS OF MIDLATITUDE F-REGION NEUTRAL WINDS AND TEMPERATURES AND AIRGLOW ENHANCEMENT/DEPLETIONS

Manfred A. Biondi

University of Pittsburgh
Pittsburgh, PA 15260

Final Report
1 September 1983 - 31 August 1984

26 October 1984

Approved for public release; distribution unlimited

AIR FORCE GEOPHYSICS LABORATORY
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
HANSCOM AFB, MASSACHUSETTS 01731

This technical report has been reviewed and is approved for publication.

Contract Manager

WILLIAM SWIDER, Acting Chief
Ionospheric Disturbances & Modification Branch

FOR THE COMMANDER

ROBERT A. SKRIVANEK, Director
Ionospheric Physics Division

This report has been reviewed by the ESD Public Affairs Office (PA) and is releasable to the National Technical Information Service (NTIS).

Qualified requestors may obtain additional copies from the Defense Technical Information Center. All others should apply to the National Technical Information Service.

If your address has changed, or if you wish to be removed from the mailing list, or if the addressee is no longer employed by your organization, please notify AFGL/DAA, Hanscom AFB, MA 01731. This will assist us in maintaining a current mailing list.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFGL-TR-84-0280	2. GOVT ACCESSION NO. A150730	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Fabry-Perot Interferometer and Skymapping Photometer Determinations of Midlatitude F-Region Neutral Winds and Temperatures and Airglow Enhancement/Depletions		5. TYPE OF REPORT & PERIOD COVERED Final - 1 Sept 83 - 8/31/84 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Manfred A. Biondi		8. CONTRACT OR GRANT NUMBER(s) F19628-83-K-0036
9. PERFORMING ORGANIZATION NAME AND ADDRESS University of Pittsburgh Pittsburgh, PA 15260		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 61102F 2310G3BC
11. CONTROLLING OFFICE NAME AND ADDRESS Air Force Geophysics Laboratory (LID) Hanscom Air Force Base, MA 01731 Monitor/W. K. Vickery		12. REPORT DATE 10/26/84 13. NUMBER OF PAGES 15
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) Air Force Geophysics Laboratory (LID) Hanscom Air Force Base, MA 01731		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

NA

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

630.0 nm airglow, nightglow, interferometry, filter photometer, thermospheric dynamics, thermospheric velocity, thermospheric temperature , airglow enhancement.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A 100 mm aperture, field-widened Fabry-Perot interferometer and a sky-mapping filter photometer were used in support of the IMS F-region chemical release program at Wallops Island, VA. On the night of the successful SF_6 release near local midnight (8/9 November 1983) the neutral wind components $\vec{v}_m$ (meridional) and $\vec{v}_z$ (zonal), as well as the neutral temperature T_n of the thermosphere were determined from 02 h UT to 06 h UT. Divergence in the zonal flow was noted. No 630.0 nm airglow enhancement/depletion was detected.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

FINAL REPORT - Contract F19628-83-K-0036

Fabry-Perot Interferometer and Skymapping Photometer Determinations of Midlatitude F-Region Neutral Winds and Temperatures and Airglow Enhancements/Depletions

Manfred A. Biondi, Principal Investigator

Dept. of Physics and Astronomy, University of Pittsburgh

I. Introduction

Passive optical observations were made of the nightglow as part of the IMS program: (1) to determine the neutral thermospheric wind vector $\vec{v}_n$ and temperature T_n as a function of time at $\sim$ 300 km altitude by high resolution measurements of the OI 630.0 nm nightglow line's doppler shifts and widths and (2) to seek changes in the nightglow morphology in the vicinity of chemical releases from Nike-Tomahawk or Sonda rockets by use of a sky-mapping filter photometer. To this end a modified Airstream trailer containing a 100 mm aperture photoelectric Fabry-Perot interferometer and tilting filter photometer, as well as a 3-channel filter photometer, was set up at the Wallops Island airfield for the duration of the IMS program.

The nightglow 630.0 nm is produced at F-region altitudes by the normal reaction sequence

$$O^+ + O_2 \rightarrow O + O_2^+ \quad \text{(charge transfer)} \quad , \qquad (1)$$

followed by

$$O_2^+ + e^- \rightarrow O^{*\prime} + O^*(^1D) \quad \text{(dissoc. recomb.)} \quad . \qquad (2)$$

A reduction in ambient F-region electron density, for example, by attachment to SF_6 molecules from a chemical release,

$$e^- + SF_6 \begin{cases} \rightarrow SF_6^{-*} \\ \rightarrow SF_5^- + F \end{cases} \quad \text{(electron attach.)}, \qquad (3)$$

should create an electron depletion which should in turn reduce the rate of dissociative recombination (reaction 2) and therefore lead to a 630.0 nm airglow depletion.

In the next sections we describe the experimental apparatus and present the results of our observations.

II. Apparatus

The field-widened, photoelectric Fabry-Perot (FP) interferometer and associated tilting filter photometer used for the 630.0 nm line doppler shift and width determinations is shown in Fig. 1. The two instruments share a common line-of-sight through the dual-axis pointing head, with the photometer used as a monitor for interfering radiation, cloud effects, etc. The 100 mm aperture FP is index-of-refraction tuned by changing the density of argon gas between the etalon plates[1]. A multiple aperture exit plate[2] provides a four-fold gain in luminosity over a conventional instrument. The stabilized laser serves as a frequency reference for the doppler shift determinations and as a monochromatic line source for instrumental broadening evaluation. The instruments are under the control of a microprocessor and microcomputer which provide data acquisition, real-time analysis and storage on magnetic tape.

The 3-channel, sky-mapping filter photometer[3] used to monitor possible airglow enhancements/depletions is shown in Fig. 2. Wavelengths monitored were 630.0 nm, 631.0 nm (background channel) and 557.7 nm by use of interference filters with passbands of $\Delta\lambda$ = 0.3 nm. A limited 38° x 38° region of the sky, centered on the expected chemical release point, was monitored by suitable adjustment of the stepping-motor-controlled scans about the horizontal (H) and orthogonal (O) axes of the pointing head mirrors. The photometer is controlled by a microprocessor and microprocessor with provision for real-time display on a color video monitor of the airglow patterns, as well as for data storage on magnetic discs.

III. Results

A. Airglow Enhancements/Depletions

As a result of the failure of the Sonda rockets to reach their intended release altitudes, the only successful release in the F-region was of SF_6 by the Nike-Tomahawk rocket on 8/9 November 1983. Although the sky was reasonably clear at the release time (there was a very thin cloud layer through which the stars shone with little apparent attenuation) and our photometer scan pattern included the release point, our data gave no clear evidence of the expected, localized depletion in 630.0 nm intensity that was larger than the slight spatial variations in the nightglow resulting from the less-than-perfect seeing conditions .

B. Thermospheric Dynamics

Measurements of the intensity and doppler shifts and widths of the 630.0 nm nightglow line were made in a number of directions, namely, looking N, S, E and W at 30° elevation and looking vertically. From these data, the neutral wind velocity components v_m (meridional) and v_z (zonal) were derived, as well as the neutral temperature T_n. The measurements were made from 0220 UT to 0635 UT (2120-0135 local time) on 09 November 1983, bracketing the rocket launch time near local midnight (0500 UT).

The meridional winds shown in Fig. 3 were poleward in the early night (as expected, since the subsolar point passed well south of Wallops Island), then changed to equatorward and increased to a maximum velocity of $\sim$ 70 m/s at 04 h UT, before decreasing through the launch period and becoming poleward once again. The zonal winds shown in Fig. 4 were anomalous in that they exhibited different behavior looking $\sim$ 500 km to the East and to the West of Wallops Island. On average, they appeared to be eastward in the early night, as expected if the solar-driven zonal pressure gradient controls the flow, but a clear convergence in zonal flow built up towards local midnight (the wind to the West was eastward and that to the East was westward), reaching a maximum (compressional) differential velocity of $\sim$ 200 m/s.

A clue to the anomalous westward flow of the zonal wind observed to the East may be seen in the 630.0 nm intensity measurements of Fig. 5, where, rather than the usual decline during the night, strong enhancements to the North and to the East suggest the presence of geomagnetic activity (energy inputs) as the source of the converging flow. The three-hour geomagnetic activity indices are shown at the top of Fig. 4, and the 24-hour sum for 9 November, $\Sigma K_p = 36$ ($A_p = 43$). This day was the second most geomagnetically disturbed day of the month.

The behavior of the neutral temperature T_n shown in Fig. 6 also differs from the smooth fall expected during geomagnetically quiet periods, indicating a significant rise in value during the local pre-midnight period in several observing directions.

Finally an interesting observation is indicated in Fig. 4, where the strongly converging zonal flow just before the SF_6 release may have largely disappeared shortly afterwards. This conceivably could result from a change in the strength of the ionospheric plasma-neutral thermosphere coupling induced by the electron attachment to the released SF_6 molecules. However, since this effect is inferred from a single, West-looking observation at 0550 UT, the result must be regarded as speculative and will require corroborating evidence from comparison with other measurements of the ionospheric behavior during the same period.

IV. Conclusions

Both the Fabry-Perot interferometer and the sky-mapping filter photometer instruments performed well in their Airstream trailer-based Mobile Observatory. Lack of ideal seeing conditions during the launch period on 9 November led to an apparent patchiness in the normally smooth 630.0 nm airglow background which could have masked a weak airglow depletion produced by the SF_6 release; in any event, our mapping photometer detected neither a depletion nor an enhancement in the nightglow.

The F-P measurements of 630.0 nm doppler shifts and widths yielded neutral velocities $\vec{v}_n$ and temperatures T_n in the thermosphere over Wallops Island which, in many respects, are typical of the observed behavior of the midlatitude thermosphere[4,5]. The fact that a geomagnetic storm was in progress during the period of observations accounts for unusual effects such as convergence in the thermospheric flow pattern and an elevation of the thermospheric temperature during a portion of the night.

References

1. D. P. Sipler, M. A. Biondi and R. G. Roble, "F-region neutral winds and temperatures at equatorial latitudes: measured and predicted behaviour during geomagnetically quiet conditions", Planet. Space Sci., 31, 53 (1983).

2. M. A. Biondi, D. P. Sipler and M. Weinschenker, "Multiple aperture exit plate for field-widening a Fabry-Perot interferometer", accepted by Appl. Optics (1984).

3. M. A. Biondi and D. P. Sipler, "Studies of equatorial 630.0 nm airglow enhancements produced by a chemical release in the F-region", Planet. Space Sci., 32, ... (1984) - December issue.

4. D. P. Sipler, B. B. Luokkala and M. A. Biondi, "Fabry-Perot determinations of midlatitude F-region neutral winds and temperatures from 1975 to 1979", Planet. Space Sci., 30, 1025 (1982).

5. D. P. Sipler and M. A. Biondi, "Midlatitude F-region neutral winds and temperatures during the geomagnetic storm of March 26, 1976", J. Geophys. Res., 84, 37 (1979).

Figure Captions

Fig. 1 Simplified diagram of the field-widened, 100 mm aperture, photoelectric Fabry-Perot interferometer, the 70 mm aperture tilting filter photometer and the two-axis pointing head used for the 630.0 nm nightglow line doppler shift and width measurements.

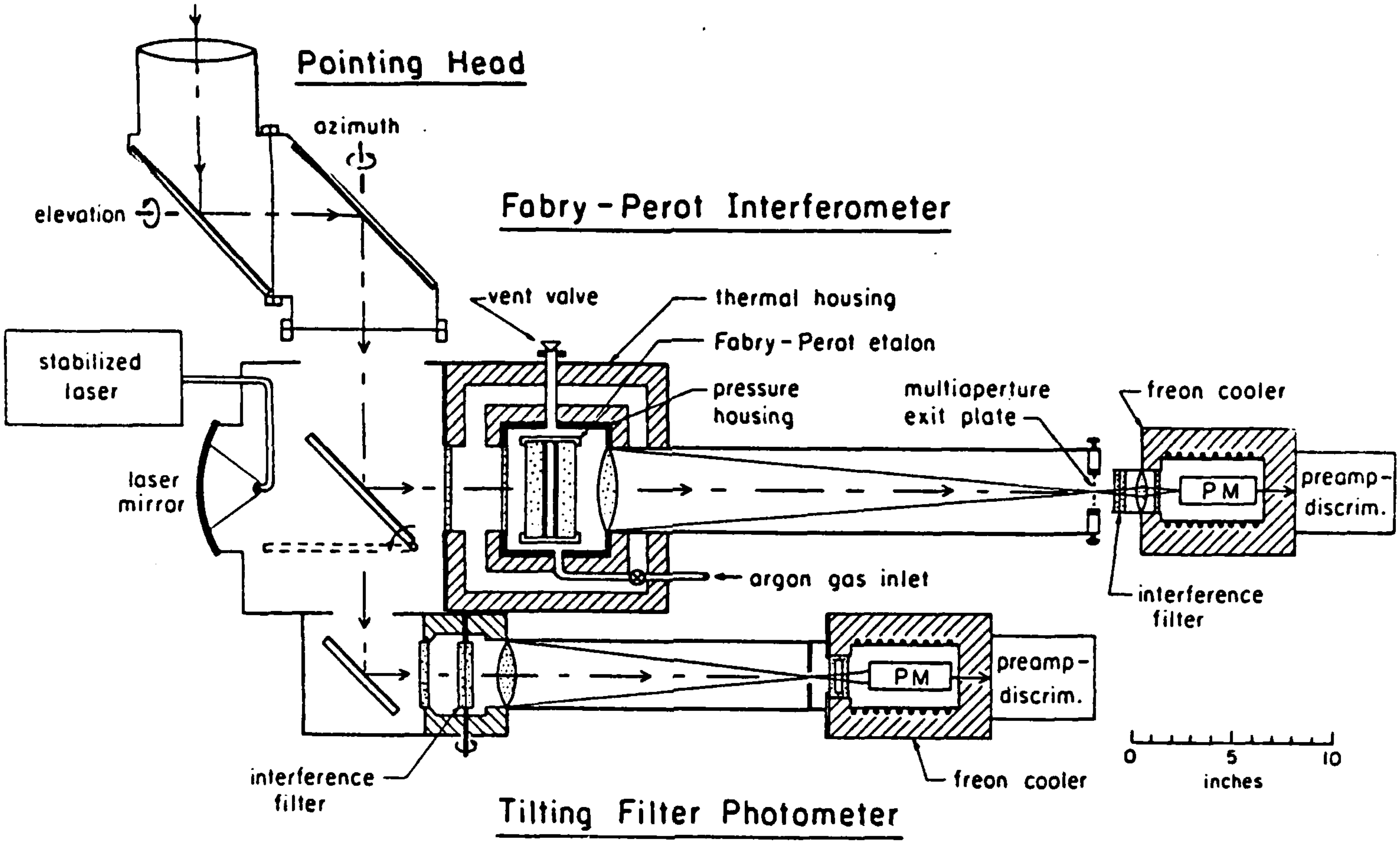
Fig. 2 Simplified diagram of the 3-channel, sky-mapping filter photometer used to monitor possible 630.0 nm and 557.7 nm airglow enhancements/depletions produced by the chemical releases in the F-region.

Fig. 3 Meridional winds (southward = positive) in the neutral thermosphere measured on 9 November 1983. The approximate launch time of the Nike-Tomahawk rocket is shown. The three-hour geomagnetic K_p indices are shown at the top of the figure.

Fig. 4 Zonal winds (eastward = positive) in the neutral thermosphere measured on 9 November 1983.

Fig. 5 The 630.0 nm nightglow intensities measured on 9 November 1983.

Fig. 6 Neutral temperatures in the thermosphere measured on 9 November 1983.



Pointing Head
azimuth
elevation
Fabry - Perot Interferometer
vent valve
thermal housing
Fabry - Perot etalon
stabilized laser
pressure housing
multiaperture exit plate
freon cooler
laser mirror
PM
preamp-discrim.
argon gas inlet
interference filter
PM
preamp-discrim.
0
5
10
inches
interference filter
freon cooler
Tilting Filter Photometer

Fig. 1

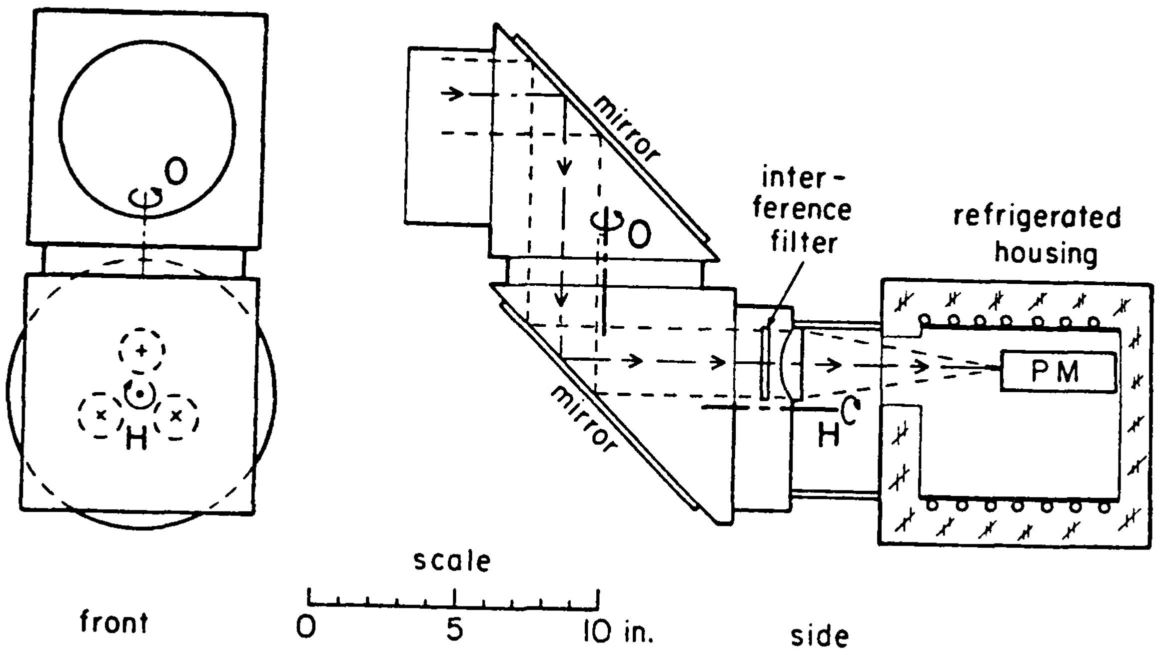

O
H
mirror
O
inter-
ference
filter
refrigerated
housing
PM
mirror
H
scale
front
0
5
10 in.
side

Fig. 2

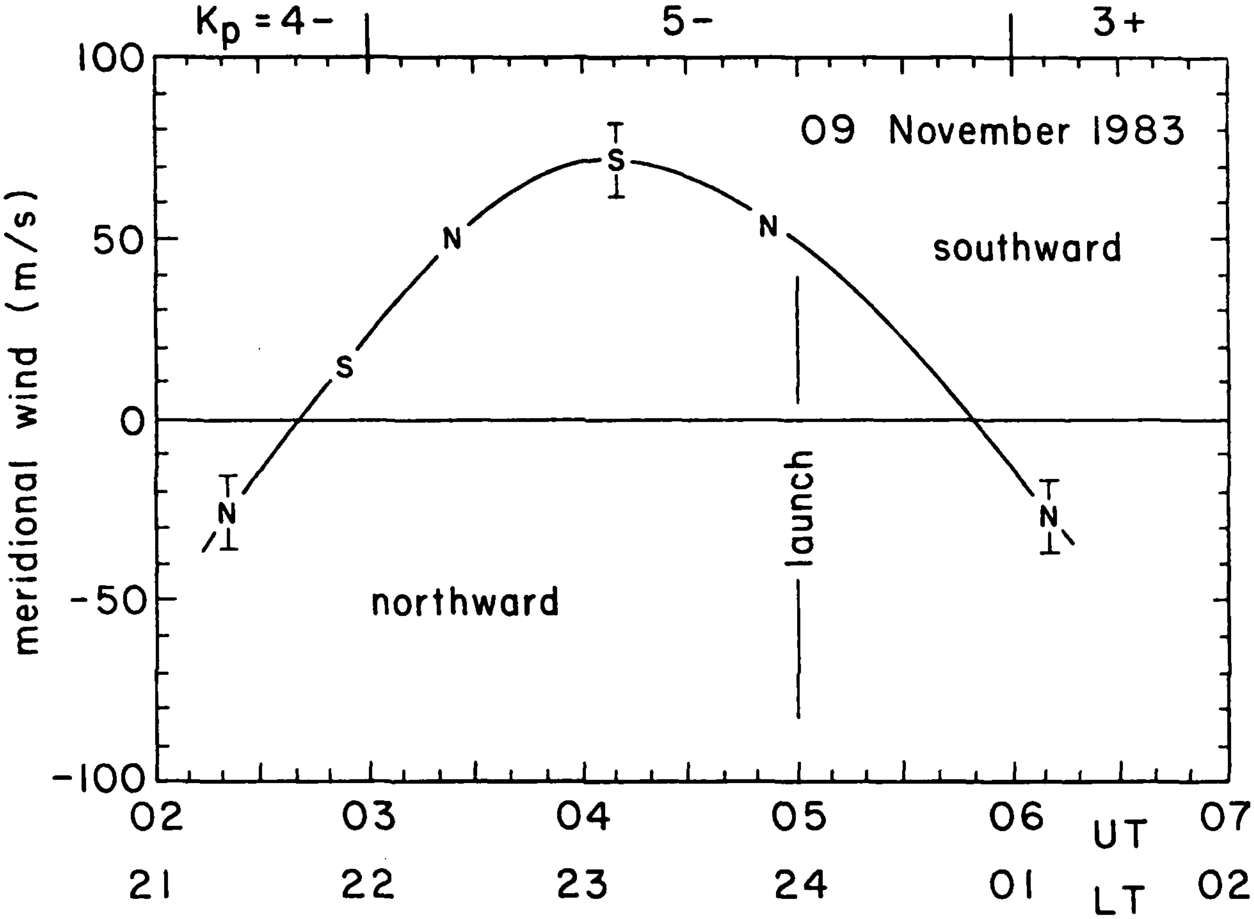
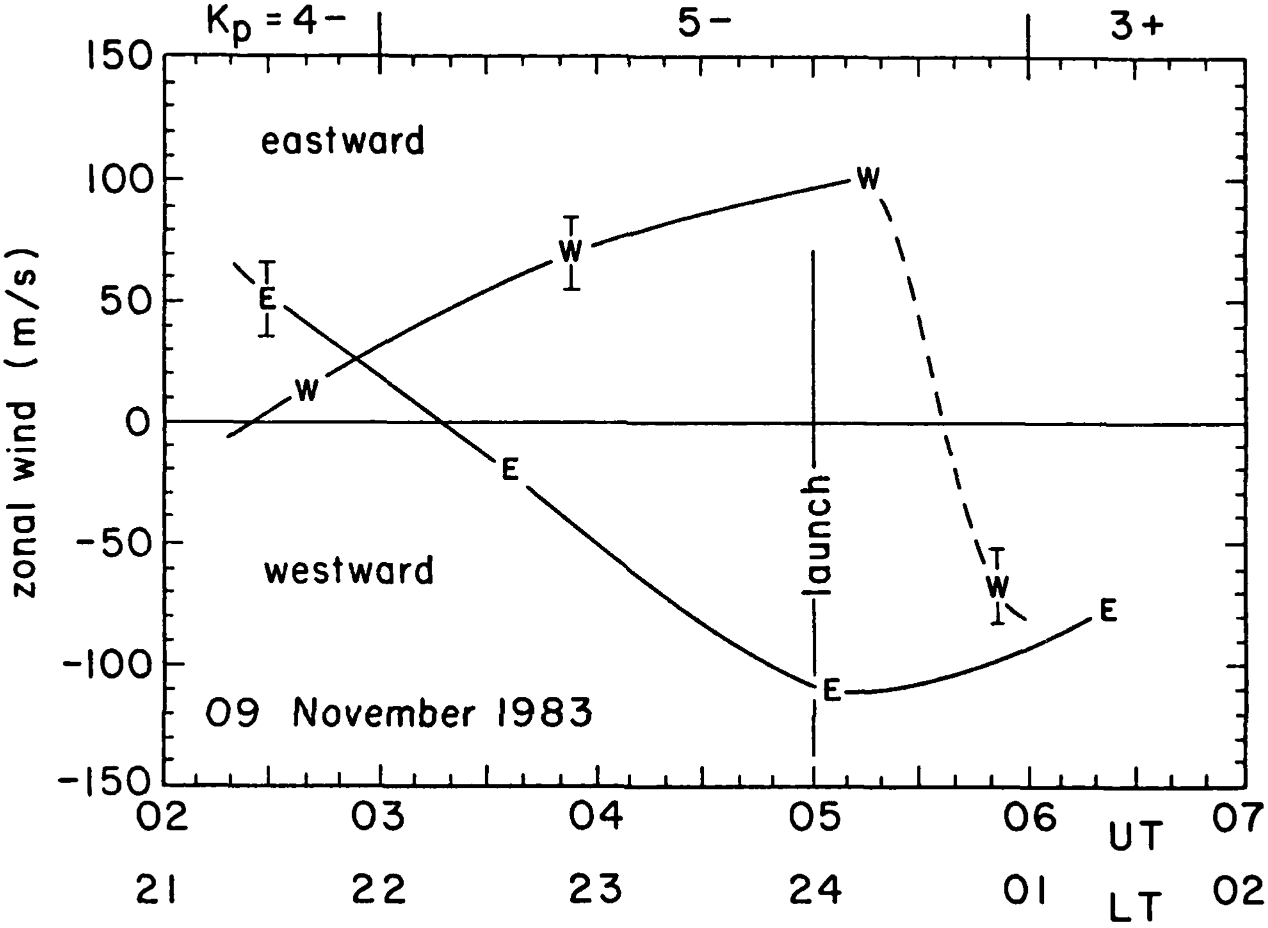

Kp = 4-
5-
3+
09 November 1983
southward
northward
launch
meridional wind (m/s)
100
50
0
-50
-100
02
03
04
05
06
07
UT
21
22
23
24
01
02
LT
S
N

Fig. 3



Kp = 4-
5-
3+
150
100
50
0
-50
-100
-150
eastward
westward
zonal wind (m/s)
launch
09 November 1983
02
03
04
05
06
07
UT
21
22
23
24
01
02
LT
W
E

Fig. 4

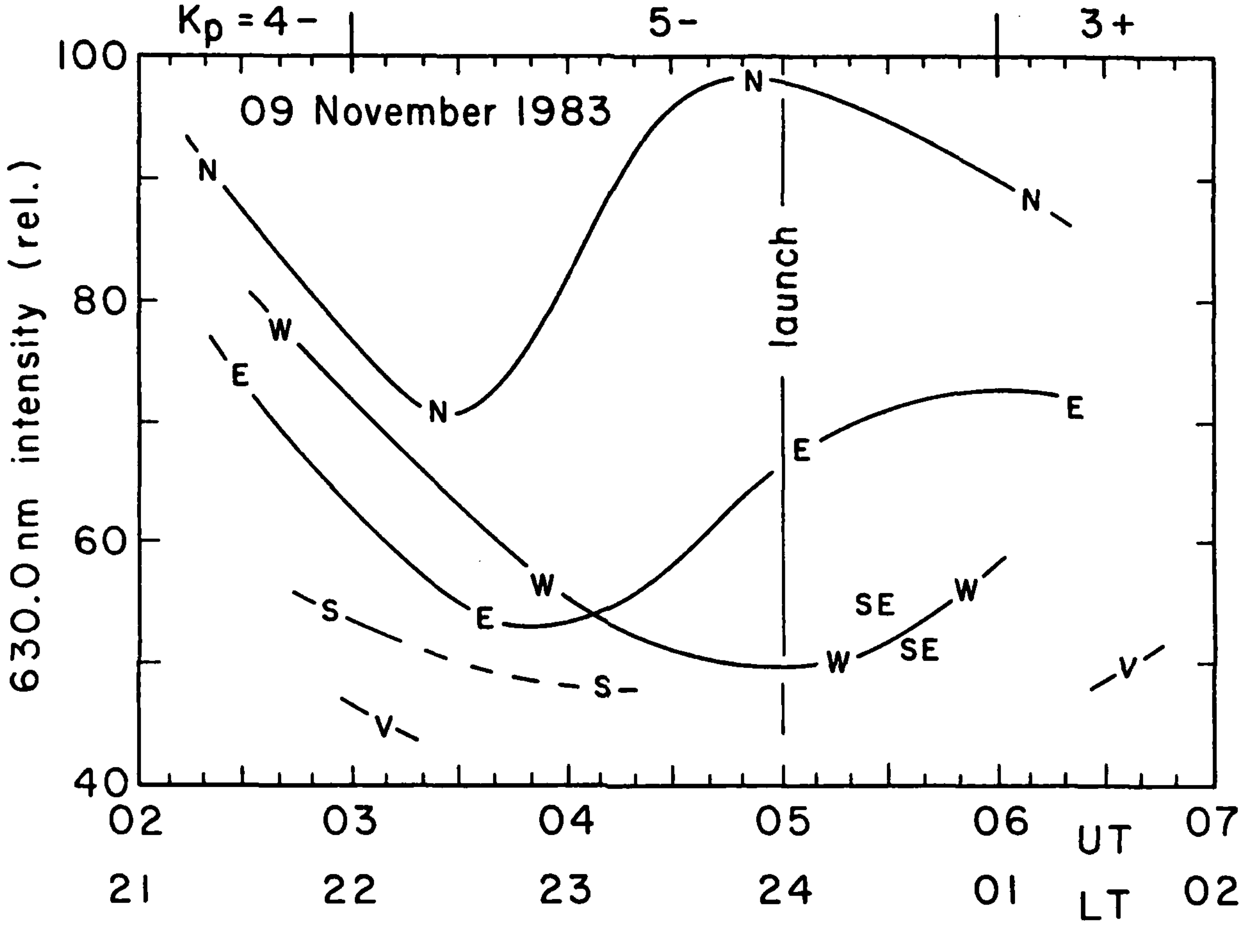
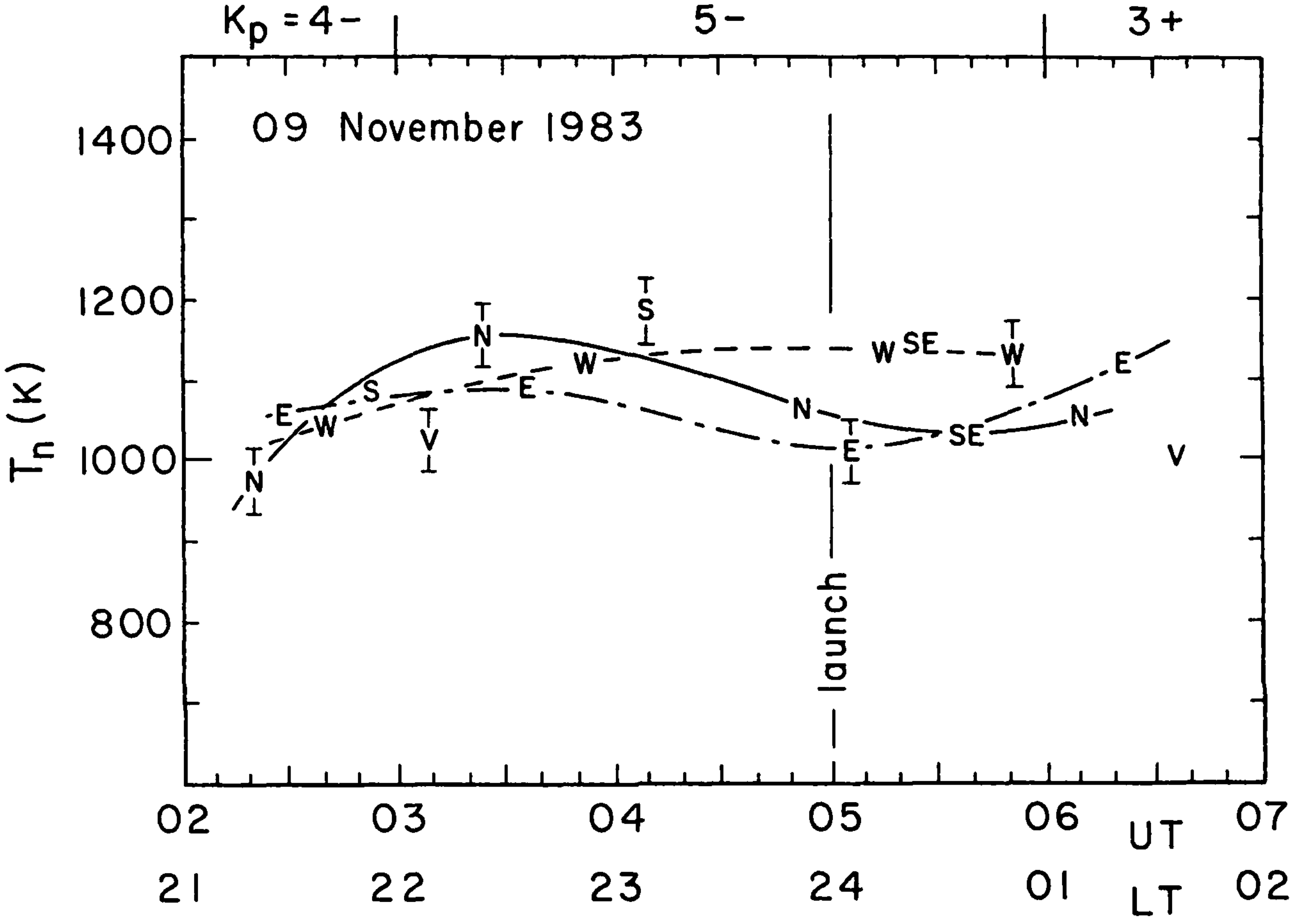

Kp = 4-
5-
3+
09 November 1983
630.0 nm intensity (rel.)
100
80
60
40
N
W
E
S
V
SE
launch
02
03
04
05
06
07
UT
21
22
23
24
01
02
LT

Fig. 5



K_p = 4-
5-
3+
09 November 1983
1400
1200
1000
800
T_n (K)
launch
N
E
W
S
V
SE
02
03
04
05
06
07
UT
21
22
23
24
01
02
LT

Fig. 6

END

FILMED

4-85

DTIC